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A FAMILIAR INTRODUCTION TO THE STUDY OF ELECTRICITY.

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A
FAMILIAR INTRODUCTION
TO THE
STUDY
OF
ELECTRICITY.

BY

JOSEPH PRIESTLEY, LL.D. F.R.S.

THE FOURTH EDITION.

NUNC OPUS EST LEVIORE LYRA. OVID.

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THE PREFACE.

WHEN I wrote *the Hiſtory and preſent State of Electricity*, I flattered myſelf that I had ſufficiently adapted it to the uſe of every claſs of readers. My principal deſign was to promote diſcoveries in the ſcience, by exhibiting a diſtinct view of the progreſs that had been made in it hitherto, and ſuggeſting the beſt hints that I could for continuing and accelerating that progreſs: but I thought that the ſame treatiſe might alſo be perfectly intelligible to beginners. It ſeems, however, that I was miſtaken in that expectation. Several perſons, on whom the experiment has been tried, have declared, that they thought it not ſufficiently intelligible to thoſe who had no previous knowledge of the ſubject, and have adviſed me to draw up a ſhort and familiar *Introduction*, for the uſe of ſuch perſons. I ſtill cannot help thinking, that, with proper attention, the former work might be ſufficient; but it may be too hard a taſk for the generality of readers to employ ſo much attention, as is requiſite to connect the diſtant parts of ſo large a treatiſe; and I would willingly do every thing in my power to facilitate the attainment of this branch of ſcience. I have, therefore, attempted a more familiar explication of the fundamental principles of electricity, mixing theory with facts, and illuſtrating, chiefly, thoſe experiments which are the moſt entertaining.

In reality, this treatiſe has the ſame object with the former: for we cannot more effectually provide for extending the ſcience, and promoting diſcoveries in it, than by making what is already diſcovered eaſily underſtood by others; for, hereby, numbers are put in a capacity of carrying the work farther, and are incited and encouraged to attempt it.

I have not directly copied a ſingle ſentence from the former treatiſe, except the deſcription of the laſt mentioned machine, becauſe I imagined it was poſſible, that, in ſome caſes, a variety in the form of expreſſion only, might aſſiſt ſome perſons, who choſe to be poſſeſſed of them both, to acquire clear ideas of the meaning. For the ſame reaſon, I have by no means ſtudied to avoid repetitions, but on the contrary, have, in ſeveral caſes, contrived to introduce them. For I know by experience, that when we are inſtructing young perſons, or thoſe who are but beginning an acquaintance with any thing, we can hardly uſe too many words, or vary the form of expreſſion too many ways; too many words being attended with a very trifling inconvenience, in compariſon of uſing too few. In the former caſe, you may give a little diſguſt

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diſguſt to perſons of a quicker apprehenſion; but in the latter caſe, perſons of ſlower apprehenſions are neceſſarily left in ignorance. This extreme, therefore, ought to be avoided with the utmoſt care.

For this purpoſe, notwithſtanding I have defined all the technical terms in the firſt part of the treatiſe, I have given a ſeparate catalogue of them in the fourth with their explications annexed, and generally in other words, for the reaſon mentioned above.

But I would adviſe all perſons who propoſe to underſtand the ſubject of electricity, though they have no expectation of making diſcoveries, to provide themſelves with an electrical machine, or at leaſt deſire ſome of their friends to ſhow them the experiments. Without this, I ſhould deſpair of making any perſon whatever a maſter of the ſubject. My own ideas were always confuſed and embarraſſed, till I had recourſe to this expedient to diſentangle them. And I would even venture to ſay, that the acuteſt philoſopher in the world could not converſe about electricity without making many miſtakes, and perhaps groſs ones, after reading every book he could meet with upon the ſubject, if he had ſeen few or no experiments.

N. B. The plates in this treatiſe are 2, 3, 6, 7, and 8 of the Hiſtory, and it was not thought neceſſary to change the numbers of them.

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A FAMILIAR INTRODUCTION, &c.

PART I.

A Series of Propoſitions, comprizing all the general Properties of ELECTRICITY; *illuſtrated by ſelect Experiments, and eſpecially the more entertaining ones.*

SECT. I.

Of the ELECTRIC FLUID.

THE earth, and all the bodies that we are acquainted with, without exception, are ſuppoſed to contain a certain quantity of an exceedingly elaſtic and ſubtle fluid, which philoſophers have agreed to term *electric*. This certain quantity belonging to all bodies, may be called their natural ſhare; and ſo long as each body contains neither more nor leſs than this quantity, it ſeems to be wholly dormant, and produces no ſenſible effect: but the moment that the equilibrium is diſturbed, and any body becomes poſſeſſed of more or leſs than its natural quantity, very remarkable effects ariſe from it. The body is ſaid to be *electrified*, and is capable of exhibiting appearances, which are aſcribed to the power of electricity.

This equilibrium could never be diſturbed, or, if it was diſturbed, would be immediately reſtored, and therefore be inſenſible; but that ſome bodies do not admit the paſſage of this electric fluid through their pores, or along their ſurfaces, though others do. By this means, whenever any body has acquired an additional quantity of electric matter, and is every where ſurrounded with bodies through which it cannot paſs, it muſt remain overloaded; or, if it has loſt part of what naturally belonged to it, it muſt remain exhauſted; becauſe the ſurrounding bodies prevent any of the fluid from going to it, or coming out of it; and the body is then ſaid to be *inſulated*. Thoſe bodies through which the electric fluid can paſs, are called *conductors*; and thoſe through which it cannot paſs, are called *non-conductors* of electricity; and into theſe two kinds all bodies whatever are claſſed by electricians.

The beſt conductors of electricity, or thoſe which admit the electric fluid to paſs through them with the greateſt eaſe, are metals of all kinds. Water is a pretty good conductor, but animal fluids conduct better than water, and charcoal is a better conductor than either. Other ſubſtances, as freſh vegetables, &c. are conductors, chiefly by reaſon of the moiſture they contain; but ſtones, and earths of various kinds, are conductors in an imperfect degree, independent of moiſture.

The moſt perfect of the non-conducting claſs of bodies are *glaſs*, *gems*, *roſin*, *ſealing wax*, *ſulphur*, *bees wax*, *baked wood*, and *dried animal ſubſtances*, among ſolids; and *oils* and *air* among fluids. But all theſe ſubſtances become conductors when they are made very hot. They are alſo called *electrics*, and the conducting ſubſtances are called *non-electrics*.

The method of diſturbing the equilibrium of the electric fluid in bodies, or of making it paſs from one to another, is chiefly friction, or a ſlight rubbing of them one againſt another. In this caſe, the electric fluid will, in general, leave that ſubſtance which has the rougher ſurface, and paſs upon the other which is ſmoother; or it will leave that ſubſtance which is the leſs perfect electric, and paſs upon the other which is the more perfect electric of the two. Thus, if I take a ſmooth glaſs tube (ſuch as is repreſented pl. 2. fig. *a*) and draw it through my hand; the effect of that friction is, that the electric matter leaves my hand, and paſſes upon the glaſs, where it will remain, as an addition to its natural quantity. For as neither the glaſs, nor the air which ſurrounds it, are conductors of electricity, this redundancy of the electric matter cannot poſſibly get away; but if my finger, a piece of metal, or any conducting ſubſtance, be preſented to any part of the glaſs, thus overloaded with the electric fluid, it will paſs immediately from that part into them; and if they be preſented to every part of the tube ſucceſſively, the whole of this redundant electricity will be diſcharged, and every thing will become juſt as it was before the operation. The glaſs, in this caſe, is ſaid to be *excited*; becauſe the friction ſeems to excite, or call up the electric power, which it had before, but which lay dormant in it.

IN like manner, when the globe is whirled in the electrical machine, the friction of the glaſs againſt the rubber (as *f*, pl. 7.) makes the electric fluid, which was in the rubber, paſs upon the glaſs; from which it is conveyed to the prime conductor (*l. k.*) the points of which (*m*) are preſented to every part of the globe in ſucceſſion. And, as the friction is continued, there will, by this means, be a conſtant ſupply of the electric matter to the prime conductor, though other bodies be preſented to it, and keep diſcharging it all the while, in viſible ſparks. The hand, in the former of theſe caſes, and the rubber in the latter, which had parted with their ſhare of the electric fluid to the glaſs, againſt which they were rubbed, receive an immediate ſupply from the conducting ſubſtances in contact with them; and theſe are, again, ſupplied by the general maſs of the fluid that is lodged in the earth.

On the contrary, if I draw through my hand a ſtick of ſealing wax, a piece of ſulphur, or a tube of rough glaſs, the effect of the friction is, that a quantity of electric matter naturally belonging to the ſulphur,

phur, &c. paſſes from it to my hand; and the ſulphur being ſurrounded by the air, which is a non-conductor, remains exhauſted, and is ready to take ſparks of electric fire from any bodies that are preſented to it. But it is impoſſible to diſtinguiſh by the eye, which way the electric matter paſſes, its velocity is ſo extremely great. The ſulphur, in this caſe, though deprived of its ſhare of electricity, is ſaid to be *excited* as well as the glaſs which was overloaded with it; becauſe, though the ſtates they are in be the reverſe of one another, the effects produced by them are, in many reſpects, ſimilar. The appearances which lead us to diſtinguiſh them, will be mentioned hereafter.

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SECT. II.

Of Electrical Attraction and Repulſion.

THE great laws of the electric fluid, and thoſe on which all the phenomena of electricity depend, are, that it is, in a much higher degree than air, elaſtic, and repulſive of itſelf; that two bodies, having both of them either more or leſs than their natural ſhare of it, repel one another; but that, if one of them have more, and the other leſs than its ſhare, they will attract one another.

Thus, if I hang a bundle of hairs or feathers upon the prime conductor, the moment I electrify them, by turning the wheel of the machine, they begin to fly from one another; ſo that ſome of them will ſtand quite erect, in a beautiful manner, and they cannot be made to collapſe, and be brought into contact with one another, till I diſcharge the conductor, by taking a ſpark from it with a piece of metal, or ſome other conducting ſubſtance. A large plumy feather, alſo, grows beautifully turgid when it is electrified, expanding its fibres in all directions; and they collapſe when the electricity is taken off.

If I hold in my hand a bundle of threads, hairs, or feathers, and preſent them to the electrified conductor, the electric fluid, with which the conductor is overloaded, repels the electric fluid from thoſe parts of the threads, &c. which are next to it, into the more diſtant parts of thoſe bodies, or into my hand, and ſo into the ground; the conſequence of which is, that the threads, having leſs than their natural ſhare, do ſtrongly repel and avoid one another: and, at the ſame time, are all ſtrongly attracted by the conductor, which is in an oppoſite ſtate. If the conductor had been deprived of its natural ſhare of electricity, the bodies preſented to them would have had more than their natural ſhare; ſo that, ſtill, the ſame appearances of mutual repulſion, and of attraction by the conductor, would have taken place; and, univerſally, all bodies that are brought within the influence of electrified bodies, whether they are ſo by having more or leſs than their natural ſhare of the electric fluid, become poſſeſſed of a contrary electricity. For the ſame reaſon, excited electrics of every kind attract all light bodies which are brought within the ſphere of their influence.

Electrical attraction and repulſion are exhibited in a very pleaſing manner, by means of a glaſs tube and a feather. When the tube is excited, by being drawn through the hand, or a rubber, the feather, when brought near it, will be attracted, and jump to the tube; then, after taking ſome time to get fully ſaturated with electric matter (becauſe, being a bad conductor, it can receive it but very ſlowly) it will ſuddenly jump from it, and fly towards the next conductor, upon which it may diſcharge the redundant electricity it has acquired. If no other body happen to be in the way, it will tend towards the ground; but if the electrified tube be held under it, it will ſtill be repelled, and driven into the middle of the room, where it may be kept ſuſpended, or be driven about in all directions, almoſt as long as a perſon pleaſes, if the air be dry.

Other beautiful effects of electrical attraction and repulſion are ſhewn at the prime conductor belonging to the machine. Suſpend a plate of metal (*o.* pl. 2.) from the conductor (*t*, which is ſupported by two pillars of baked wood, and muſt be ſuppoſed to be ſupplied with electricity from the globe) and underneath it, at the diſtance of about three or four inches, put another plate of the ſame ſize (*n*). Upon the lower of theſe plates lay a feather, or a ſmall ſlip of light paper; and, as ſoon as the wheel begins to turn, the feather or the paper will be attracted, and jump to the upper plate; from whence it will be immediately repelled, and fly to diſcharge itſelf upon the lower; after which it will be ready to be attracted and repelled again. Thus will the feather, or paper, fly from the one plate to the other alternately, and with inconceivable rapidity, if the electrification be pretty vigorous. When the pieces of paper are cut into the figures of men and women, they exhibit a kind of dance, which is extremely amuſing.

This experiment will be the more diverting, if it be accompanied with that of the *electrical bells* (*l.* pl. 2.) which depends upon the ſame principle. Two bells hang by a chain, from a braſs rod communicating with the prime conductor, and another bell, with a chain faſtened to it, reaching to the ground, hangs in ſilk from the ſame rod between them; and a ſmall braſs ball, ſuſpended by a ſilken thread, hangs between each two bells. The conſequence of this diſpoſition is, that the two outermoſt bells, which hang from the prime conductor by braſs chains, are electrified, and attract the braſs balls which hang in ſilk; and the attraction being vigorous, they are made to ſtrike the bells with ſome force, and make them ring. Being then loaded with electricity,

tricity, they are immediately repelled from theſe outermoſt bells, and fly to unload themſelves, by ſtriking upon the middle bell, which hangs in ſilk; and from which the electric matter paſſes to the floor, by means of the chain hanging to it. The braſs balls, which may now be called clappers to the bells, are then ready to be attracted by the outermoſt bells, as at firſt; and thus the ringing may be continued as long as it is agreeable. The amuſement will be heightened, if the operator now and then touch the prime conductor with a braſs rod, or with his finger; for then the dancing and ringing will ceaſe, and will not be renewed till the finger or rod be removed. If he conceal this application of his finger, or the rod, with a little art, the figures will ſeem to dance, and the bells to ring, at the word of command.

SECT. III.

Of the Electric Spark.

WHEN I preſent a piece of metal, or any other good conducting ſubſtance, to the overloaded prime conductor, the electric matter will paſs with violence from the one to the other; an electric ſpark, with the appearance of fire, will be ſeen darting between them, and a report, which is uſually compared to a ſnapping noiſe, will be heard. If the piece of metal that is preſented to the prime conductor be inſulated, ſo that it cannot immediately loſe what it receives, it will take only part of the charge from the prime conductor (the whole of the redundant electricity being divided between them, in proportion to their ſurfaces) and either of them will give a ſmaller ſpark to another body that is preſented to them.

When any perſon ſtands upon the ſtool, with feet made of glaſs, or baked wood (ſuch as is repreſented fig. *c.* pl. 2.) and takes in his hand a chain faſtened to the prime conductor; being then inſulated, he may be conſidered as part of the prime conductor; and any part of his body will exhibit all the ſame appearances which the prime conductor itſelf will do. Thus, if the finger of any perſon ſtanding upon the floor be preſented to him, a ſpark of fire will ſeem to iſſue from him, and both he and the perſon that receives it will feel a painful ſenſation, like a pricking; and the ſame ſnapping noiſe above-mentioned will be heard. Every part of his body will then attract light ſubſtances; and the bits of feathers, or the human figures above mentioned, cut in paper, and laid upon a plate, will perform the ſame dances that were mentioned before, if the palm of his hand be expanded over them. Alſo, the hairs of his head, or of his wig, if they happen to be looſe, will repel one another, and many of them will ſtand upright, as it is ſaid they will do when a perſon is greatly frightened. As theſe electric ſparks, which are attended with a ſenſation moderately painful, will be excited wherever he is touched, or wherever he touches any other perſon, this experiment often furniſhes very great diverſion. Care, however, ſhould be taken, that no ſparks be drawn from the eyes, or any part that is peculiarly tender; becauſe it may produce an inflammation, which may have bad conſequences. If either of the perſons concerned in this experiment hold a braſs rod in his hand (ſuch as repreſented fig. 5. pl. 2.) and give or receive the electric ſparks upon the knob of it, he will feel very little; while the perſon to whoſe naked ſkin it is preſented, will feel as before.

The electric ſpark has not only the appearance of fire, but is capable of actually ſetting fire to various ſubſtances, that are eaſily inflamed: but the inflammation is probably produced by the rapid motion into which the parts of the ſubſtances are thrown, by the action of the electric matter upon them. Thus, if ſpirit of wine, a little warm, be held in a ſpoon, and an electric ſpark be drawn from the ſpoon, ſo as to paſs through any part of the ſpirit, it will catch fire, and burn as if it had been lighted by a candle. The ſpoon, in which the ſpirit is contained, may either be connected with the prime conductor, and the ſpark drawn through it by a perſon ſtanding on the floor; or the ſpoon may be held by a perſon ſtanding on the floor, and the ſpark be drawn through it by a braſs rod, either connected immediately with the prime conductor, or held in the hand of a perſon ſtanding on the ſtool, in the manner mentioned above. If a candle be blown out, and an electric ſpark be immediately drawn through the ſmoke, it will often be lighted again; but it requires a pretty ſtrong ſpark, and ſome degree of dexterity and experience in the operator to produce this effect with certainty. It will be more amuſing, and the effect be as certain, if the ſpark be drawn through the ſpirit by the end of a perſon's finger, or even by a piece of ice.

NOT only are the ſenſes of feeling, ſeeing, and hearing, affected by electricity, in the manner deſcribed above, but it is even ſenſible to the ſmell, and the taſte. If a pointed braſs rod be electrified, either by being faſtened to the prime conductor, or held in the hand of a perſon electrified, and another perſon, ſtanding upon the floor, preſent his noſtrils within an inch or two of the point, he will feel a ſtrong and diſagreeable ſmell, like that of burning ſulphur; and if he receive the electric effluvia iſſuing from the point, upon his tongue, he will perceive a taſte, which is manifeſtly acid.

SECT. IV.

Of the Influence of Points in Electricity.

THE more acutely pointed any bodies are, the more eaſily do they take or part with the electric matter. Thus, if a needle, or ſharp pointed wire, be faſtened to the prime conductor, it will retain but a ſmall degree of electricity, and conſequently, will give but a ſmall ſpark, when the finger, or a piece of metal is preſented to it. Alſo, if the needle, or ſharp pointed wire, be held in the hand of a perſon ſtanding upon the floor, and preſented to the conductor, it will, likewiſe, be found to retain but a ſmall degree of electricity. In the former of theſe caſes, while the needle was in contact with the prime conductor, the electric matter went off at the point, and was diſperſed in the air, or among the conducting particles which are always floating in the common atmoſphere. In the latter caſe, the needle, being preſented towards the conductor, through the ſpirit by the end of a perſon's finger, or even by a piece of ice.

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IF theſe experiments be made in the dark, a flame will be ſeen at the point of the needle or wire; but the appearances of the fire will not be the ſame in both caſes, but conſiderably different; ſo that it may always be perceived by the eye, whether, according to the common theory, the point be receiving or giving out the electric matter.

IF the ſharp pointed wire be giving out the electric matter, the flame will be large; the parts of which it conſiſts will be fewer; and, if the point be not very acute, a kind of ſnapping noiſe will be heard as the electric matter is iſſuing out of it into the air; whereas, if the pointed wire be receiving the electric matter, the flame will be much ſmaller, and more globular; the parts of which it conſiſts will be more in number, and the noiſe that is made will be a kind of hiſſing.

THESE appearances are diſtinguiſhed by different names in moſt foreign languages; and ſometimes, in Engliſh, the flame iſſuing from a body, on account of its oblong form, is called a *pencil*; and the latter, becauſe it is more round, and the rays of which it conſiſts project more equally from the center, is called a *ſtar*.

THE reaſon why pointed bodies tranſmit the electric fluid with ſo much eaſe, has not yet been thoroughly explained, but the effects of it are exceedingly remarkable. The capital uſe that has been made of this obſervation, has been to draw the electric matter from the clouds, and thereby to prove, that lightning and electricity are the ſame thing. For if a long rod, or pole, with a ſharp pointed wire at one end of it, be ſupported by electric ſubſtances, the point, projecting towards the clouds, will draw the electric matter from them, and become ſenſibly charged with electricity; juſt as it would have been from being connected with the prime conductor of an electrical machine. It will attract light bodies, ſparks of electric matter may be drawn from it, and it will exhibit every other appearance of common electricity; as, on the other hand, by common electricity, we can produce, in miniature, all the known effects of lightning.

Several amuſing experiments depend on this property of pointed bodies, to tranſmit the electric fluid. If a plate of tin be cut into the form of a ſtar, and be ſupported on its center by a wire projecting upwards from the prime conductor; as ſoon as the wheel of the machine is turned, and this apparatus electrified, a flame will appear at the extremity of every angle of the ſtar, which will be very beautiful; and if the ſtar be made to turn ſwiftly on its center, an intire circle of fire will be ſeen in the dark. This experiment will be very ſurprizing to perſons unacquainted with electricity, if the operator now and then privately touch the prime conductor, which may eaſily be managed as it is performed in the dark; for, by this means, he may command the appearing or diſappearing of the ſtar, or circle of fire, at pleaſure.

IF a ſharp pointed wire be bent, with the two ends at right angles, in the ſame plane, but pointing different ways, and be made to turn upon a center (ſee *m*. pl. 2.) the moment it is electrified, a flame will be ſeen at each point: but what is moſt ſurprizing in the experiment, is, that the wire will, at the ſame time, begin to turn round, in the direction oppoſite to that to which the points are turned, as if ſome inviſible power acted upon the points and puſhed againſt them; and, if the electrification be continued, the motion will preſently become very rapid. If the figures of horſes, cut in paper, be faſtened upon theſe wires, and they be ſo contrived, that the points ſhall be in their tails, the experiment will be very beautiful; the horſes will ſeem to purſue one another, though without a poſſibility of either of them overtaking the other; and this is called the *electri-*

cal horſe-race. It is poſſible to make ſeveral of theſe wires, each having a conſiderable number of points bent backwards, with horſes, &c. faſtened to each of them, and turning one above another; and, then ſome of them may be contrived to move faſter than the others. They may alſo be made to move different ways.

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SECT. V.

Of Poſitive and Negative Electricity.

THE electric matter, with which the prime conductor is loaded, is not produced by the friction of the globe againſt the rubber. It is only collected by that operation from the rubber, and all the bodies that are contiguous to it. So that if the rubber be well inſulated, by being ſurrounded on all ſides by electric ſubſtances, the friction of the globe will produce little or no electricity. For, in that caſe, the rubber can only part with its own ſhare of electric matter, which is very inconſiderable. In this ſituation, if a braſs rod, or a finger, be preſented to the rubber, a ſpark will be ſeen to dart from them to the rubber, to ſupply the place of that electric matter which had paſſed from it to the globe; and if the prime conductor be inſulated as well as the rubber, theſe ſparks will ceaſe as ſoon as it is fully loaded; but they will flow very faſt, if a chain be hung upon the prime conductor, in order to connect it with the floor; for, by this means, all the fire which is drawn from the finger, or any other bodies preſented to the rubber, and which paſſes by the way of the globe to the prime conductor, will be conveyed to the ground; ſo that the rubber will be kept continually exhauſted, all the electric matter it receives being immediately conducted from it to the common maſs in the earth.

If, in this caſe, that is, while the prime conductor is connected with the floor, by a chain hanging from it, another inſulated conductor (as *t*, pl. 2.) be connected with the rubber (which is likewiſe inſulated) it will, like the rubber, of which it may be ſaid to be a part, be deprived of its natural ſhare of electricity by the friction of the globe. It will, therefore, have leſs than its natural ſhare, and, conſequently, be ready to take electricity from any bodies that are preſented to it. Now, becauſe, in this caſe, it ſeems to act like the former prime conductor, when it was electrified, this is ſaid to be electrified too; but to diſtinguiſh them from one another the former is ſaid to be electrified *poſitively*, having more than its natural ſhare of the electric fluid; whereas the latter is ſaid to be electrified *negatively*, having leſs than its natural ſhare.

These two electricities, though they are the reverſe of one another, are, in many reſpects ſimilar, and produce the ſame ſenſible effects. All the difference that is viſible between them, is in the appearance of the electric fire at the points of bodies electrified poſitively and negatively, which was mentioned above. If the wire be electrified poſitively, that is, if it be connected with the poſitive conductor, or preſented to the negative conductor, what is called the *pencil* of electric light appears; but if the wire be electrified negatively, that is, if it be connected with the negative conductor, or preſented to the poſitive conductor, the *ſtar* will be ſeen.

If a globe of ſulphur, ſealing wax, or baked wood, be uſed, and the rubber be the human hand, or a piece of leather, the effects in all the caſes mentioned above, will be the very reverſe of thoſe produced by a globe of glaſs; for the friction of the ſulpur and this rubber will make the electric matter paſs from the ſulphur to the rubber; the conſequence of which will be, that the inſulated prime conductor will give all the electric matter it is poſſeſſed of to the globe, and remain exhauſted, or negatively electrified; whereas, the rubber, and the conductor connected with it, will, for the ſame reaſon, be overloaded, or electrified poſitively.

If any body have received a ſpark of one of theſe electricities, a ſpark of the other kind will unelectrify it. Thus, if two perſons be inſulated, ſtanding upon ſtools with feet of glaſs, or baked wood, and one of them be electrified poſitively, and the other negatively; either of them, being touched by a perſon ſtanding on the floor, will give a moderate ſpark; but if they touch one another, the ſpark will be much ſtronger, and they will both be unelectrified as effectually as if they had been touched by a perſon ſtanding on the floor. In this caſe, one of theſe perſons having more, and the other leſs than his natural ſhare of electricity, the effect of their communication will be, that the redundancy of the one will juſt ſupply the defect of the other; ſo that, after contact, they will both remain in their natural ſtate, and will give no ſpark at all upon being touched by a perſon ſtanding on the floor. But if both theſe perſons had been electrified poſitively, or both negatively, there would have been no ſpark upon their touching one another; for both being overloaded, or both being equally exhauſted, the electric matter could no more paſs from the one to the other, than it could from one part of the ſame body to another part of it. Theſe perſons, therefore, touching one another, would be the ſame thing as either of the perſons making one of his hands touch the other; and, after contact, they would, either of them, give or take a ſpark, upon being touched by perſons ſtanding on the floor, juſt as they would have done, if they had never touched one another at all.

THE difference between poſitive and negative electricity will be farther illuſtrated, when I treat of the charging of electric ſubſtances in the next ſection. I would obſerve, that it is not very eaſy to inſulate a rubber ſo perfectly, as that there ſhall be no conſtant ſupply of electric matter to the globe, and to the prime conductor through it. To ſucceed the beſt, the globe ſhould be very large, and the rubber very ſmall and round; for if there be any ſharp point or edge about it, it will be impoſſible to prevent its receiving a ſupply of electricity from the atmoſphere; and if the globe were made ſo very large, and the rubber ſo very ſmall, as would be neceſſary for the complete demonſtration of theſe facts, the friction would not produce a quantity of electricity for other experiments. But it is very eaſy to inſulate the rubber ſo much, that the ſupply it receives from the atmoſphere ſhall not be very conſiderable; ſo that the ſparks which are given to it, or to a conductor connected with it, ſhall, to all appearance, be as large and ſtrong, as thoſe drawn from the prime conductor ſupplied by the globe itſelf; that is, the negative electricity, produced in this manner, ſhall be as powerful as the poſitive.

SECT. VI.

Of Charging Electric Subſtances

IT was obſerved before, that the electric matter in one body repels the electric matter in another, when it is brought within the ſphere of its influence, and makes it retire into the more remote parts of the ſame body, or into other bodies that are contiguous to it. This will explain the nature of what is called the *charging* of glaſs, and other electric ſubſtances. If a plate of glaſs (which is impermeable to the electric fluid) have a plate of metal in contact with each ſide of it, not coming nearer than an inch or two of the edge (ſee *b*, pl. 2.) and one of theſe plates of metal (which, in this ſituation, are called the *coating* of the glaſs) be made to receive a ſpark of electric matter from the prime conductor, while the plate on the other ſide of the glaſs has a free communication with the earth; the redundancy of the electric matter now thrown on one of theſe plates, and one ſide of the glaſs, will extend its influence to the other plate, and the other ſide of the glaſs; and repelling the electric matter which was natural to them, will make it retire into the next conductors. If the former ſide be made to receive a greater quantity or charge of the electric fluid, the other ſide will, for the ſame reaſon, continue to be more and more exhauſted, till at length one of the ſides will have received as great an additional quantity of electric matter as it can receive, and the other will be exhauſted as far as poſſible.

In this ſtate, the plate of glaſs is ſaid to be *charged*; the meaning of which is, that one of the ſides has gained an additional quantity of the electric matter, and the other has loſt as much as was equal to it. In other words, one of the ſides is electrified poſitively, and the other negatively, and both in the ſame degree. Or, again, as it is ſometimes expreſſed, the equilibrium of the fluid, naturally belonging to the glaſs, is deſtroyed, part of it being removed from one ſide, and transferred to the other.

The diſcharge of this plate of glaſs is made, by reſtoring the equilibrium, which was deſtroyed by the charging; and it is effected by forming a communication between the overloaded and the exhauſted ſide; and if the communication be made by metal, or other very good conductors, the equilibrium will be reſtored with violence; the redundant electricity on one ſide will ruſh, with great rapidity, through the metallic communication to the exhauſted ſide, and a large exploſion will be made; that is, the flaſh of electric light will be very viſible, and the report will be very loud.

The reaſon why the equilibrium cannot be reſtored, without forming an external communication betwixt the poſitive and negative ſide of the glaſs, is, that the electric matter cannot paſs through the ſubſtance of the glaſs, on account of its being a non-conductor; and therefore, though the diſtance between the poſitive and negative ſide be ſo very ſmall, and the attraction between them, as was explained above, ſo very great, the plate would always remain charged, if the moiſture in the air, or ſome other conducting ſubſtances, did not ſerve to convey the electric matter from one ſide to the other.

The poſſibility of charging a plate of glaſs to ſo great a degree, as we ſee it is, in fact, capable of bearing, ſeems to argue, that the ſubſtance of glaſs naturally contains a very great quantity of electric matter; becauſe no addition of electricity can be thrown upon one ſide of the plate, but an equal quantity muſt leave the other; which, therefore, muſt have exiſted in its pores, or have lodged on its ſurface before. That it is not contained in the metal, which forms the coating, is evident, becauſe the plate of glaſs is capable of being charged without the coating, as will be explained hereafter.

The thinner the glaſs is, the ſtronger is the charge which it is capable of bearing; becauſe the electric matter, which is added to one ſide, is nearer to the electric matter which belongs to the other ſide of the glaſs, and therefore can act upon it with more force, and, conſequently, expel a greater quantity of it.

Sometimes, when a plate of glaſs is charged very high, and eſpecially, if it be very thin, it will explode of itſelf, and a hole will be made through the glaſs. In this caſe, a white ſpot is made in the glaſs, a part of it being abſolutely pulverized; and very often cracks extend, in all directions, from every ſide of the hole.

Other electric ſubſtances may be made to receive a charge of electricity. Even *air* may be uſed for this purpoſe; for plates of metal hanging parallel to one another, and, conſequently, having a plate of air, as it may be called, between them, exactly reſemble the coatings of a plate of glaſs, with the ſubſtance of the glaſs between them.

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THE ſhape of the glaſs is of no conſequence with reſpect to its power of receiving a charge; and, in general, the moſt commodious form is that of a phial or jar. Jars are more eaſily removed from place to place, and may be handled and managed more eaſily than flat plates of glaſs. Beſides, leſs of the glaſs is loſt in this form than the other; for, in order to prevent the plate or the jar from diſcharging itſelf, by the electric matter jumping from one of the coatings to the other, it is neceſſary that they be kept at a conſiderable diſtance from one another: and two or three inches on every ſide of a flat plate of glaſs, which muſt be left uncoated, is much more than two or three inches of the neck of a jar; particularly, if it be made very narrow. Alſo, the uncoated part, being ſmall, may be more eaſily wiped, and kept clean and dry, in a jar, than in a plate. The forms of ſeveral coated jars, &c. as fit for different purpoſes, may be ſeen in plate 2, fig. *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, *k*.

As it is indifferent which ſide of a plate of glaſs be charged with electric matter, and which ſide be exhauſted, ſo it is equally eaſy to charge either the inſide or the outſide of a glaſs jar. If the inſide be charged, the outſide will be exhauſted; and if the outſide be charged, the inſide will be exhauſted. To charge the inſide of a jar, the braſs rod, which touches the inſide coating, muſt be preſented to the prime conductor, and the outſide held in the hand, or touch ſome conducting ſubſtance communicating with the earth. To charge the outſide, the rod muſt be held in the hand, and the outſide coating be preſented to the prime conductor. If, after this, a perſon ſhould chuſe to quit his hold of the braſs rod, and take the jar by the outſide, he muſt firſt ſet it down upon an electrical ſtool or ſtand, and then he may lay hold of it wherever he pleaſes, without giving himſelf a ſhock.

If the prime conductor be electrified negatively, preſenting to it the wire, which communicates with the inſide of the jar will exhauſt the inſide, and, conſequently, charge the outſide; and if the outſide be preſented, that will be exhauſted, and the inſide charged.

If a cork be put in a jar, or a phial, and the wire be made, with a hook, to hang upon the prime conductor (as *k*, pl. 2.) it may eaſily be proved, that no electric matter can enter the inſide, except an equal quantity can paſs from the outſide; for while it hangs from the prime conductor it is incapable of being charged, unleſs the outſide be touched by the hand, or ſome other conducting ſubſtance, which may give the electric matter, that is lodged on the outſide of the glaſs, an opportunity of making its eſcape, as faſt as any additional quantity is thrown into the inſide.

If two jars be charged alike, either both the inſides poſitively, and, conſequently, both the outſides negatively, or the reverſe; and if their outſides be connected by a chain, and their wires be brought together, there will be no exploſion; for both of them being in the ſame circumſtances, either loaded or empty, neither of them has any thing to impart which the other wants. But when one of them is charged poſitively, and the other negatively, and a chain connects their outſides; then, if their wires be preſented to each other, there will be a great exploſion, and both will be diſcharged: for the one being loaded, and the other exhauſted, the electric matter will ruſh from the one to the other; and this will be done with eaſe, as, the outſides being in contact likewiſe, a like paſſage of the electric matter will, at the ſame time, be made through the chain, whereby the charge which lay on the outſide of the one of them, will paſs into the outſide of the other, which was exhauſted.

It may alſo be known, by a very pretty experiment, whether two jars be charged alike, or differently. Let them ſtand near together, and eſpecially upon a plate of metal. In this ſituation, if a cork ball, or a feather, be hung in a ſilken ſtring, and brought to one of the wires, it will catch ſome of the electricity, of whatever kind it was, and will be immediately repelled; and it will alſo be repelled from the other wire, if that jar had been charged in the ſame manner; and ſo long as any electricity remains in the ball or feather, it cannot be made to touch either of them; but if the other jar be charged differently, the cork ball, or feather, will fly between them with great rapidity, taking from the one and giving to the other, till both be diſcharged.

When a jar is charged either poſitively or negatively, before it can be charged the contrary way, the former operation muſt be reverſed; and, as it cannot be perceived by the eye, which way an electric ſpark goes, whether into the jar, or out of it, it is amuſing to ſee a jar, already charged, ſeem to be receiving a greater charge, and yet, after ſome time, be found to have no charge at all. This will be the caſe, if, when it has been charged at a poſitive conductor, it be afterwards taken to a negative one, and be held to each about the ſame number of turns of the wheel. It is difficult, however, to hit the exact time when the firſt charge ſhall be taken out, and no oppoſite charge be thrown into it.

To make the nature of charging and diſcharging a jar the eaſier to young electricians, *k*. pl. 2. repreſents a jar hanging by its wire from the prime conductor, while a chain connects the outſide with the table. In this ſituation, if the wheel of the machine be turned, it will receive a charge, and may then be removed from the prime conductor. To diſcharge it, the braſs rod, *s*, being held in contact with the chain, which touches the outſide of the jar, muſt be brought to the braſs knob at the end of the wire; or it may be brought to any part of the prime conductor, if the wire remain in contact with it, as it was while it was charged, and have not been removed from it. In either of theſe caſes, a flaſh of fire will be ſeen at the braſs knob, or at the prime conductor, and a report will be heard; but the perſon who makes the diſcharge will feel nothing of it, though he holds the chain and rod in his hand, the fire paſſing directly through them without entering any part of his hand, in order to go the neareſt way, and through the beſt conductors, to come to the other ſide of the jar. For when a jar is charged, the diſcharge is always made the neareſt way, through the beſt conductors. But the electric matter will go a great way through a better conductor, as through metals, rather than a very ſhort way, through a worſe conductor, as moiſt wood or water. And it has not been found, that it takes the leaſt ſenſible ſpace of time in paſſing through the greateſt diſtances.

When a phial, or plate of glaſs, is charged without any coating, that part only receives the charge, which is in the neighbourhood of the wire, or other conducting ſubſtances that touch it; but if the wire from the prime conductor be made to touch all the parts of it in ſucceſſion, while the other ſide is touched by the hand, or any conducting ſubſtance communicating with the earth, the naked glaſs will be charged as high as the coated. But then, for the ſame reaſon, it can only be diſcharged partially, thoſe parts only being diſcharged which are in contact with the extremities of the electric circuit, and the parts in the neighbourhood of them. However, in general, a glaſs jar, of no great dimenſions, may be more than half charged, or diſcharged, by bringing the conductor in contact with only one part of it.

If a bottle, with water in it, be uſed, without any coating on the outſide, it will be charged very well, provided it be held in a perſon's hand while the wire receives ſparks from the prime conductor; or, if the outſide be touched by another wire, which is now and then removed from one part of it to another. And, if one end of the diſcharging rod touch the outſide of a bottle charged in this manner, and touch the wire communicating with the inſide, with the other end, the jar will be more than half diſcharged. In this caſe, the phial makes a fine appearance; for, from the place where the diſcharging rod touches the outſide of the phial, the fire will ſeem to branch out, and make the moſt beautiful ramifications all over the phial, and in the dark, will give an intenſe light.

If any part of the human body be made a part of the electric circuit, or be ſo placed, that the fire of the jar muſt paſs through it, in its way from one ſide to the other, a violent ſhock is given, which affects the nerves and muſcles like a convulſion. Thus, if a perſon touch the outſide of a charged jar with one hand, and bring the other hand to the wire communicating with the inſide, the fire will ruſh from the inſide of the jar (if it was charged poſitively) and paſs through his arms and breaſt, as its neareſt way to the outſide. If a number of perſons join their hands, and a perſon, at one extremity of the circuit, touch the outſide of the jar, while another perſon, at the other extremity, touches the wire, the fire muſt, for the ſame reaſon, paſs through all their arms and breaſts, and they will all feel the ſhock alike. When many perſons thus join their hands, and take a ſhock together, the experiment is very entertaining. It is particularly amuſing to the operator, to obſerve how a number of perſons, who never felt a ſhock before, are affected by it, and to hear them deſcribe their ſeveral feelings.

Electric ſhocks may alſo be given to any particular part of the body, without affecting the reſt, by bringing that part only into the electric circuit. Thus, if I would give a ſhock to my arm only, I make the braſs chain, which communicates with the outſide of the jar, touch my ſhoulder, while a diſcharging rod is held in my hand: and, in this manner, the fire may be made to come in and go out at whatever place a perſon pleaſes. But if the charge be ſtrong, the parts in the neighbourhood will be affected, as well as thoſe which lie directly in the path of the fire.

To make this operation the eaſier, Mr. Lane has contrived an inſtrument, *r*, pl. 2. and *c*. fi. 2. pl. 6. It conſiſts of a braſs rod, put through a braſs ball, ſupported by a pedaſtal of baked wood. By means of an index annexed to it, the knob of this rod may be placed at any given diſtance from the wire of a jar, or the prime conductor, with which it communicates. In this ſituation, if one end of a wire, twiſted about this braſs rod, touch one part of the body, while another wire, from the outſide of the jar, touch any other part; as ſoon as the jar is charged ſo high, that the exploſion can paſs the interval between the rod and the wire, there will be a diſcharge, and the part of the body between the two wires above-mentioned, will be ſhocked. If things remain in this ſituation, the operator need only to keep turning the wheel of the machine, and the patient will receive as many ſhocks, of preciſely the ſame ſtrength, as he pleaſes.

IF a few leaves of a quire of a paper, or the cover of a book be intercepted in the circuit of an electrical exploſion, they will be perforated by the diſcharge, and the hole will give a ſtrong ſmell of ſulphur.

A NUMBER of jars combined make what is called an *electrical battery*, ſuch as is repreſented, pl. 3. where all the jars ſtand in a box, the bottom of which is covered with tin. The wires belonging to one of the jars are all made to connect with one rod, which has a braſs knob at each end; and all the rods, or any number of them, may be connected by a braſs chain laid over them.

THE effect of a conſiderable force of electricity, thus accumulated, is much greater than could well be imagined from what can be done by a ſingle jar. If a ſmall wire be made part of a circuit, it will be made red hot, be melted, and even calcined, vitrified, or totally diſperſed. If gunpowder be placed in contact with this ſmall wire, it will take fire upon the exploſion; as alſo, if it be made up into a cartridge, and two wires (part of the circuit) be placed at the diſtance of about a quarter of an inch from one another, in the inſide of it.

When the ſurface of water, the leaves of vegetables, the fleſh of animals, and ſome other conducting ſubſtances, of a middle claſs, are made part of the circuit, and the diſtance is not very great, the electric fire, inſtead of paſſing through theſe ſubſtances, will often paſs viſibly over the ſurface, giving a prodigiouſly intenſe light, and making a report far exceeding that which is made when the exploſion is received between two pieces of metal. If the fire of the charge enter the water, &c. inſtead of paſſing over the ſurface, the ſound of the report is very dull, and the colour of the ſpark is red, which is univerſally the caſe when the electric circuit conſiſts of bad conductors.

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SECT. VII.

Of the Electric Light in Vacuo.

SOME of the fineſt appearances of electric light are exhibited in *vacuo*. For, in paſſing through the air, which is a non-conductor, it is confined, as it were, to a narrow path, and a ſhort diſtance; whereas it diffuſes and ſpreads itſelf to a greater diſtance in vacuo; and the medium making no reſiſtance, the electric ſpark may be made of any length whatever. If a tall receiver, with a wire inſerted into the top of it, be exhauſted, the electric ſpark, taken at the knob of the wire, will dart through the whole length of the vacuum to the plate on which the receiver ſtands, and in its paſſage, will ſpread itſelf, and divide in a moſt beautiful manner.

In vacuo, the difference between poſitive and negative electricity is very remarkable.

It is only the pointed wire electrified poſitively, that will throw out the beautiful ſtreams of electric light mentioned above, which extends itſelf from one end of a tall receiver to the other. If the point be electrified negatively, there will be at the end of it a kind of a ball of fire, conſiſting of rays ſo ſmall, as to be hardly diſtinguiſhable ſeparably, and which will not form themſelves into large and denſe ſtreams. However, the appearance is very pleaſing. If the vacuum be made a part of the electric circuit, the fire of an exploſion will dart through the very center of it, in the form of a compact ball of fire, be the diſtance ever ſo great. Whereas, when ſingle ſparks are taken, the electric matter not ruſhing with ſo much impetuoſity, is generally attracted to the ſides of the glaſs, along which it runs, in a variety of currents, which frequently change their courſe.

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SECT. VIII.

Of the Methods of aſcertaining the Kind and Degree of Electricity.

IN many electrical experiments, it is very convenient to have a method of determining, whether a ſmall degree of electricity be poſitive or negative; and, in uſing large batteries, it is a matter of conſequence to know how the charge advances, and of what ſtrength it is. Mr. Canton's balls are extremely uſeful for both theſe purpoſes. They are made of the pith of elder turned perfectly globular, and ſuſpended by fine threads, in a ſmall box, as repreſented upon the glaſs ſtanding on the ſtool, *c*, pl. 2.

To underſtand the uſe of them, ſuppoſe a jar or battery ſtand upon the table, and I want to know whether the inſide be charged poſitively or negatively. In order to this, I preſent the balls, and they are immediately attracted by the wire, and diverge from one another. This is common to both electricities, and the greater the diſtance to which the balls ſeparate, and the farther they repel one another, the higher is the charge. To determine of what kind it is, I rub a ſmall piece of glaſs (which I carry about with me for the purpoſe) againſt my hand, or coat, which I know will excite it poſitively, and then preſent it to the balls in their diverging ſtate. If it make the balls converge and conſequently avoid the glaſs, it ſhews that they are electrified poſitively, as well as the glaſs. On the contrary, if it increaſe their divergency, and attract them, it ſhows their electricity to be of a kind oppoſite to that of the glaſs, that is, negative. And it muſt be remembered, that the electricity of the balls (which do not touch, or receive any electricity from the wires of the jar, or battery) is always contrary to that with which they are charged; for, as was explained above, all bodies placed within the influence of electrified bodies, are affected with the contrary electricity.

In order to aſcertain the kind of an exceedingly ſmall degree of electricity, it will be convenient to have a very light body, as a piece of a downy feather hanging by a ſilken thread. This light body, when it is once electrified, either poſitively or negatively, will retain its virtue a long time, with very little loſs. If then, any body, the electricity of which is unknown, be brought to it, the feather will be repelled by it, if it be of the ſame kind with its own, and attracted, if it be contrary to it. The ſilk, by which it is ſuſpended, ſhould be a ſingle thread, as it comes from the worm, or at leaſt, a very few of thoſe threads, and the whole ſhould be as light as poſſible.

The force of a ſhock, after the exploſion, may be meaſured by Mr. Lane's electrometer, mentioned above; and by Mr. Kinnerſley's, which is repreſented *q*, pl. 2. as faſtened to the ſame pedeſtal which ſupports Mr. Lane's. It conſiſts of a cylinder of glaſs, through the caps of which are inſerted braſs rods with knobs, which may be placed at any diſtance from one another. Theſe are made part of the electric circuit, and the fire of the diſcharge darts from the one to the other. The force of the charge is meaſured by the quantity of air diſplaced by the paſſage of the electric matter; and this is ſhewn by a ſmall glaſs tube, inſerted with cement through the upper cap, and let into a ſmall quantity of water at the bottom of the cylinder, which will riſe in the tube, in proportion to the force exerted upon it by the diſplacing of the air.

PART II.

Practical Directions for uſing ELECTRICAL MACHINES, *and for conducting* ELECTRICAL EXPERIMENTS.

WHEN the air is dry, and particularly when the wind is north, or eaſt, electrical machines will always act to the beſt advantage. If the air be moiſt, the globe ſhould be made very clean and dry, before it be uſed; and then, if there be a fire in the room, and eſpecially if the rooms adjoining to it have fires in them likewiſe, the ſtate of the air will be no impedient to excitation.

To increaſe the quantity of electric matter, in order to a vigorous electrification, the rubber ſhould not be kept quite dry; for a ſlight degree of moiſture is a great advantage to it, though too much will entirely prevent the excitation. But nothing has yet been found of ſo much uſe, as putting a little amalgam upon the rubber. An electrician will ſeldom be without tinfoil, for the purpoſe of coating jars; and the amalgam is readily made, by working the waſte pieces of it with a little quickſilver in the palm of the hand, till it be of the conſiſtence of paſte. A very little of this will ſerve a conſiderable time; for, by frequent uſe of the amalgam, an incruſtation will be formed upon the rubber, which is a much better covering to it than the ſurface of the leather itſelf. After this, a little moiſture, but more eſpecially a little tallow, will generally do as well as freſh amalgam; or ſcraping it a little now and then, ſo as to take away the inequalities which will be formed upon its ſurface, will anſwer the ſame purpoſe.

As all the electricity with which the prime conductor is ſupplied, is collected from the neighbouring bodies, and paſſes through the rubber; it is neceſſary that the rubber have a free communication with the earth, by means of good conducting ſubſtances. If the wood of the machine, or of the table, therefore, be very dry, a chain, or a piece of wire ſhould hang from the rubber to the floor.

If a ſmooth glaſs tube be uſed, the beſt rubber for it is a piece of oiled ſilk, with a little of the ſame amalgam put upon it. I have ſeen a little bees-wax drawn over the tube, before the friction, have a very great effect. When the ſmooth tube is in very good order, pencils of electric matter will dart into the air from ſeveral places of it ſpontaneouſly, and make a very beautiful appearance.

If a rough tude be uſed, in order to electrify negatively, the beſt rubber will be a piece of new ſoft flannel, or the ſkin of a hare or a cat. The manner in which the electric matter ſpreads upon the ſurface of a rough glaſs tube, when a perſon's knuckle, or any other conducting ſubſtance, is preſented to it, immediately after the friction, is very pleaſing.

The larger the prime conductor is, or rather, the greater ſurface it has, the greater quantity of electric matter it will retain, and the ſtronger ſparks it will give. The prime conductor may be made ſo large, that ſingle ſparks taken from it ſhall be equal to a ſhock from a charged phial. But the leſs the prime conductor is, the leſs loſs there is of the electric matter by diſſipation into the atmoſphere, and therefore, the more convenient it is for charging jars and batteries. The longeſt ſparks may be drawn from the prime conductor at thoſe parts of it which are the moſt remote from the globe.

The uncoated part of glaſs jars ſhould be kept clean and dry, in order to contain as great a charge as poſſible. It is alſo very uſeful to warm them a little before they are uſed. This will often render the wiping of them unneceſſary, and is more eſpecially adviſeable in large batteries, as it would require a conſiderable time to wipe every ſingle jar. This, however, ſhould be done when they are very duſty, though duſt alone, if it be quite dry, occaſions little or no obſtruction to the charging; whereas, the ſlighteſt degree of moiſture, connecting the inſide and the outſide coating, will effectually prevent the charge. In order to charge jars and batteries with the moſt eaſe, it is adviſeable to connect their outſides by a wire or chain to the rubber. By this means, the very ſame electric matter which was diſlodged from the outſide, is tranſferred to the inſide; and in this caſe alſo, the dryneſs of the table, or of the wood of the machine, is no hindrance to the charge being carried as high as poſſible.

A medium ſhould be obſerved in coating jars, in order to make them hold the greateſt charge. If they be coated very high, ſo that the two coatings be near together, the charge can be but very moderate; ſince, before it can be carried to any conſiderable height, a ſpontaneous diſcharge will be made, by the fire jumping from one coating to the other, without the help of any circuit of conducting ſubſtances. But, on the other hand, if the two coatings be very far aſunder, there will be left only a ſmall part of the ſurface of the glaſs on which the charge can lodge, and, therefore, it muſt be proportionably ſmall. Beſides, in this caſe, the danger of the burſting of a jar by a ſpontaneous diſcharge is the greater, the diſtance of the coatings admitting it to be charged to a very great height. Theſe ſpontaneous diſcharges, by burſting the glaſs, are a great inconvenience in large batteries, and, therefore, the jars which compoſe them ſhould be coated higher than jars which are uſed ſingly.

I SHALL conclude this chapter of precepts, with adviſing all young electricians to be exceedingly cautious in uſing large batteries, and to be ſure that they are perfectly maſters of a ſmall force, before they meddle with greater. So great a force of electricity as may be accumulated in batteries is not to be trifled with; ſince the conſequences, if not fatal, may be great and laſting. A large ſhock taken through the arms and breaſt (which an operator is moſt in danger of receiving) might poſſibly injure the lungs, or ſome other vital part; and if the ſhock were taken through the head, which may very eaſily happen, when a perſon is ſtooping over it, in order to adjuſt the apparatus belonging to an experiment, it might affect his intellects in ſuch a manner, as that they ſhould never be what they were before.

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PART III.

A Deſcription of the more convenient Forms of ELECTRICAL MACHINES.

THE principal part of every electrical machine, is, generally, a globe or cylinder of glaſs; and the uſe of the machine is to give it a convenient friction, and to provide a prime conductor, to collect and retain the electric matter excited by it.

THE moſt elegant of the portable machines that I have ſeen, is that of which a repreſentation is given, pl. 6. fig. 1. *b* repreſents the globe, which turns upon a vertical axis *c*, by means of a handle *d*, and the wheel-work 1 contained in the box *a*; *e* is the rubber, which may be made to preſs hard by means of the ſcrew *f*; and *g* is the prime conductor, ſuſpended on ſilken ſtrings in the frame *b*.

FIG. 2. of the ſame plate repreſents a machine, which is alſo faſtened to a table, and is peculiar uſeful in medical electricity: *d* repreſents the cylinder turning on a vertical axis, which goes through the center of it, and is ſupported by the bow *e*. Motion is given to this cylinder by means of a pully *f*, and the wheel *g*. The prime conductor *a* is a tin tube, furniſhed with points, and firmly fixed to the wire of a coated jar *b*. When the wheel is turned, this jar is charged; and the machine annexed to it is that which was mentioned before, as being uſeful to aſcertain the force of a ſhock. When common electrification is wanted, this coated jar is taken away, and an uncoated jar, of the ſame ſize, which effectually inſulates the conductor, put in its place.

PLATE 7. repreſents a machine, which I think is peculiarly adapted to philoſophical purpoſes: *a a* repreſent two parallel boards firmly jointed at the ends, from which ariſe two pillars, one of them, *b*, fixed, and the other moveable in a groove cut in the upper board. This frame is ſcrewed to a table. The globe has only one neck, and is turned on an horizontal axis *d* (ſupported by a braſs arm *c*) by a pulley, and a wheel, which is fixed in a frame of its own, *e*, and which is alſo ſcrewed to the table. The rubber is ſeparated from the ſpring *h*, which ſupports it, by a piece of baked wood, *g*, which effectually inſulates it. The ſpring may be moved in any direction, by means of the groove, and the ſcrew underneath it. The ſmall ſcrew, *i*, makes it preſs more or leſs at pleaſure; and the chain *n* connects the rubber and the floor, when poſitive electricity is wanted. The prime conductor *k* is a piece of hollow copper, in the ſhape of a pear, ſupported by a pillar of baked wood, and pierced with holes, for the inſertion of braſs rods, to convey the electricity wherever it may be wanted. It is ſupplied with electric matter by means of an arched wire *l*; and the ſmall pointed wires, or needles, *m*, which play lightly upon the globe.

A Globe of any ſize may be uſed in this machine, as the fixed pillar is pierced with a variety of holes, by means of which the axis, and all the apparatus belonging to it, may be placed higher or lower at pleaſure. Alſo globes, or cylinders with two necks, and an axis going through them, may be whirled in it, by means of the moveable pillar, which is perforated in the ſame manner as the fixed one. The chief convenience of this machine, beſides the eaſy inſulation of the rubber, and its receiving a globe, or glaſs veſſel of any form or ſize, is, that the frame, the wheel, the globe, the rubber, and the prime conductor (which is perfectly ſteady) admit of every variety of poſition to one another.

The machine repreſented in pl. viii. is conſtructed on the ſame general principles with the laſt. It is inferior to it in one reſpect, that it admits only of globes or cylinders with one neck; but theſe are far preferable to any other; and it is much more commodious for uſe, as it doth not require any ſtrong table like the other. It conſiſts of a pillar of mahogany, *a*, ſtanding upright on three feet. This pillar divides in two places, to receive a wheel, *b*, in the lower part of it, and in the upper part a pulley, *c*, which is turned by a leathern ſtrap, *d*, tightened by means of a ſmall buckle. In the center of the pulley is a ſtrong iron ſpindle, turning in two firm braſs ſockets, faſtened to each ſide of the pillar. In one of theſe ſockets the extremity of the ſpindle turns upon a center, by means of a piece of iron, *e*, ſcrewed into it, while the other is held tight by a braſs claſp, which may be made to hold it cloſer, or more looſely, at pleaſure, by means of a ſcrew, *f*. The iron ſpindle is made hollow in the form of parallelopiped, in order to receive a piece of braſs or iron, in which the braſs cap that holds the globe *g* terminates. Theſe are exactly fitted by one another, and by this means any globe may be taken out, and another put into the machine with very little trouble, if theſe parts be always made to the ſame pattern.

The rubber, *h*, is ſeparated from the ſpring, *i*, by a plate of glaſs, *j*, which effectually inſulates it; but the chain, *k*, connects them together when poſitive electricity is wanted, as in the uſual method of electrifying. The ſpring may be made to preſs more or leſs, by means of a ſcrew, *l*; and it may be raiſed higher or lower, to ſuit globes of different ſizes, by means of a contrivance which is not repreſented in the plate.

The prime conductor, *m*, *n*, *o*, is the ſame as in pl. vii. From the ſame board which ſupports it ariſes another pillar, at the top of which is Mr. Lane's electrometer; the knob of which, *p*, may be placed as near to the knob oppoſite to it on the prime conductor, *q*, as is deſired, by means of the graduated part, *r*. But the whole of this may be taken away when it is not wanted.

When negative electricity is deſired, the chain, *k*, muſt be removed from the rubber, and hung upon the prime conductor, ſo as to connect it with the table; and a ſhort braſs rod, with a knob at the end of it, muſt be ſcrewed into a ſmall ſocket, which will be found in the rubber above the plate of glaſs. This braſs rod will then ſerve for a negative prime conductor; for, in this ſituation, when the wheel of the machine is turned, this rod being inſulated (together with the rubber, through which all the electric fire paſſes to the globe) will receive ſparks from whatever is preſented to it, and therefore electrify negatively.

As it requires ſome dexterity and experience to turn the machine, ſtanding on three feet only, without ſhaking it, ſmall plates of braſs, upon which the edges of heavy weights, made of lead or iron, may be placed, are faſtened to two of them; but a large board may be firmly ſcrewed under all the feet, or various other methods may be uſed, whereby the pillar, which ſupports the machine, may ſtand as firm as a perſon chuſes.

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PART IV.

An Alphabetical Catalogue of the TECHNICAL TERMS *uſed by Writers on the Subject of* ELECTRICITY.

BATTERY, electrical, a number of jars combined together, ſo that they may all be charged and diſcharged at the ſame time. The form of one is exhibited, pl. 3.

Charging, throwing an additional quantity of electric matter upon one ſide of a plate of glaſs, or a jar, while the other ſide is exhauſted in the ſame proportion. All other electric ſubſtances are capable of being charged as well as glaſs.

Circuit, electric, thoſe conducting ſubſtances which are made uſe of to form a communication between the two coatings of a charged jar, or battery, &c. and through which the electric matter muſt paſs, when the equilibrium between the two ſides is reſtored by the diſcharge.

Coatings, plates of metal, or other conducting ſubſtances, laid upon plates of glaſs, or other electrics, whereby the additional quantity of electric matter, called *the charge*, may be the more eaſily and uniformly conveyed to them, or diſcharged from them.

Conductor, prime, a piece of metal furniſhed with points, to receive the electric matter from the globe, after it has been excited by friction. It muſt always be inſulated, or cut off from a communication with the earth by means of electric ſubſtances, ſuch as *glaſs*, *baked wood*, &c. Whenever *the conductor* is mentioned, the prime conductor muſt always be underſtood.

Conductors, or *conducting ſubſtances*; thoſe bodies through which the electric matter may be tranſmitted. They are alſo called *non-electrics*, becauſe no electric powers can be excited in them by friction.

Diſcharging, reſtoring the equilibrium of the electric fluid, after it has been diſturbed by charging. It is effected by forming a communication between the overloaded and the exhauſted ſide of a glaſs jar, battery, &c. by means of conducting ſubſtances, through which the overplus, or charge, may paſs from the one to the other. When the diſcharge is conſiderable, it is often called an *exploſion*.

Diſcharging rod, a braſs rod, with a knob at each end (ſee *s*, pl. 2.) very convenient either for taking ſparks from the prime conductor, or for diſcharging jars or batteries. It is ſometimes bent into a ſemicircular form in order to bring one of the knobs to the outſide, and the other to the wire communicating with the inſide of a charged jar, in order to diſcharge it, by receiving the exploſion on its knob.

Electric matter, that ſubtle fluid which is ſuppoſed to be the cauſe of all thoſe appearances which are termed *electric*. It is ſometimes called *electric fire*, and ſometimes *ether*.

Electrics, thoſe bodies in which electric powers of attraction, repulſion, &c. may be excited by friction. They are alſo called *non-conductors*, becauſe the electric matter cannot paſs through them.

Electrometers, inſtruments to meaſure the degree of electrification (that is, the quantity of electric matter thrown upon any body) or the force of an electrical exploſion.

Excitation, the act of exciting, or calling forth, electric powers from electrical ſubſtances, by means of friction, and other methods.

Inſulating, placing bodies where they are not in contact with any conducting ſubſtance; as by ſuſpending them in the air by ſilken ſtrings, putting them on glaſs ſtands, &c. ſo that the electricity they may be charged with cannot be conveyed to the earth.

Negative electricity, a leſs quantity of the electric matter than is natural to any body.

Pencil, the appearance of electric light iſſuing from the point of a body electrified poſitively.

Poſitive electricity, a quantity of electric matter thrown upon any body, above its natural ſhare.

Rubber or Cuſhion, a piece of leather, or any other ſubſtance, againſt which the glaſs globe, or other electric body whirled in the machine, is rubbed in order to excite them.

Shock, electric, the convulſion given to the animal muſcles by the paſſage of the electric matter through them, eſpecially in the diſcharge of a jar or battery.

Star, the appearance of electric light from the point of a body electrified negatively.

Wire of a phial, jar, or battery, the wire or metal rod which goes into the inſide of a phial, and which touches the inſide coating. This wire is therefore often put for the inſide coating.

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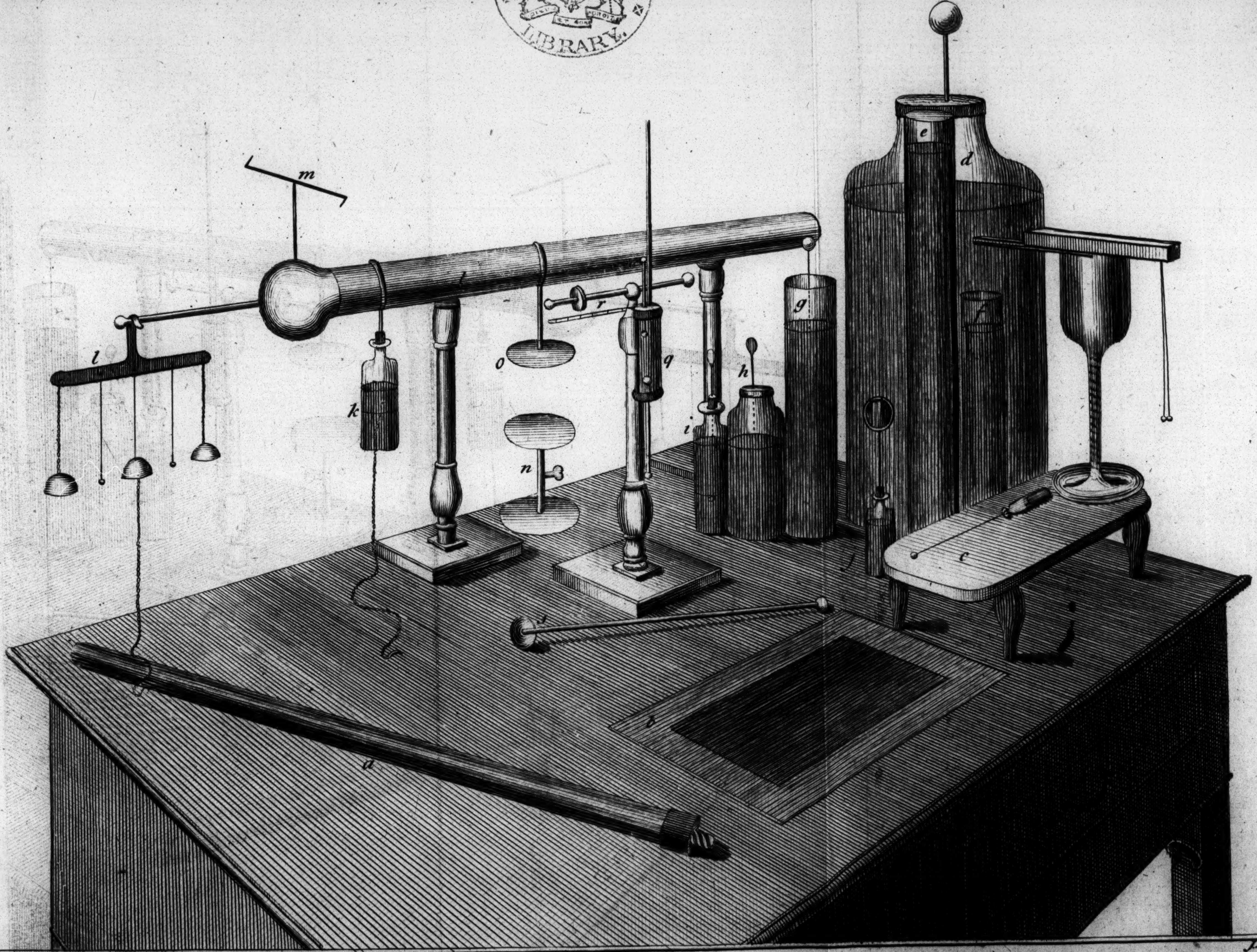

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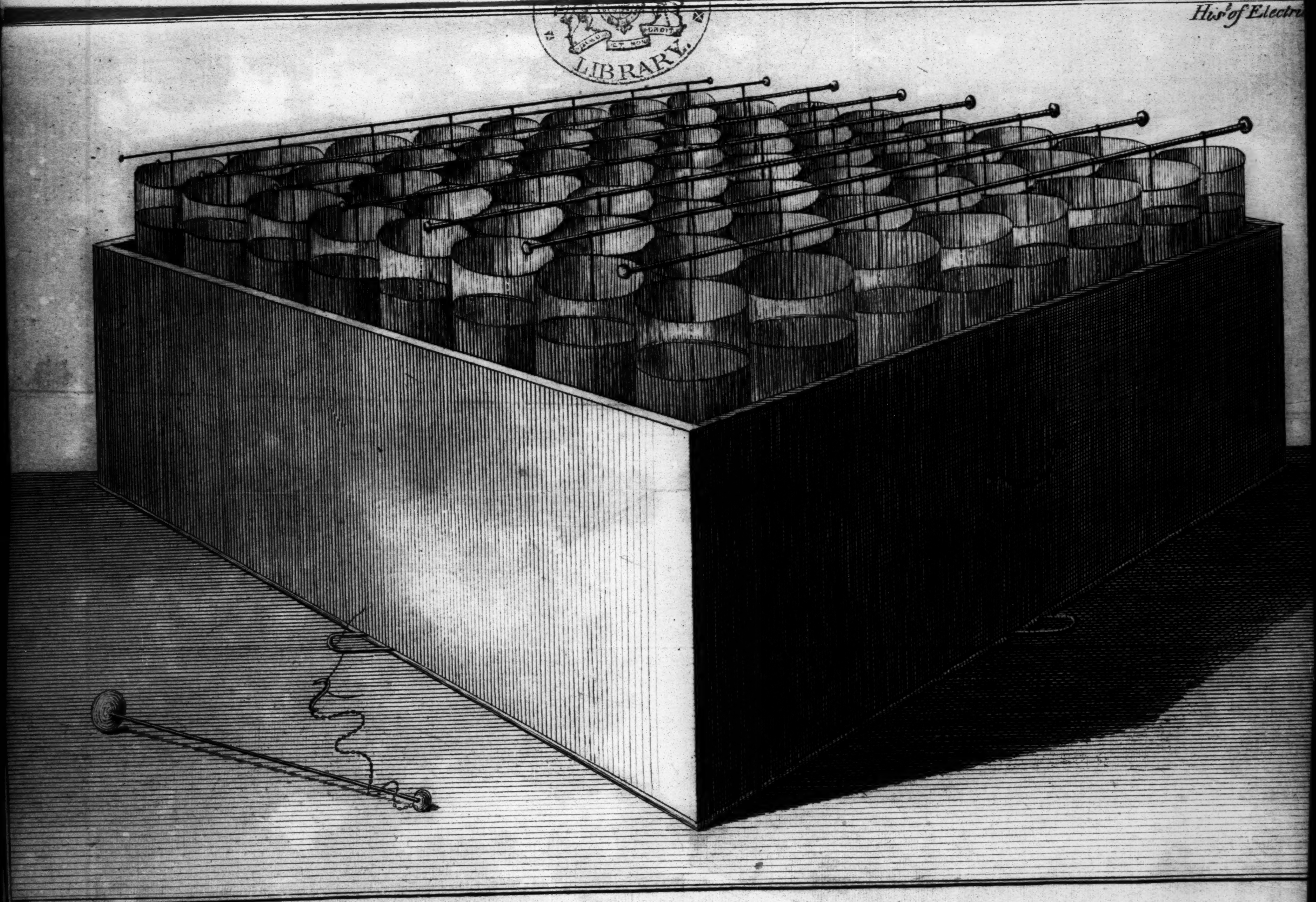

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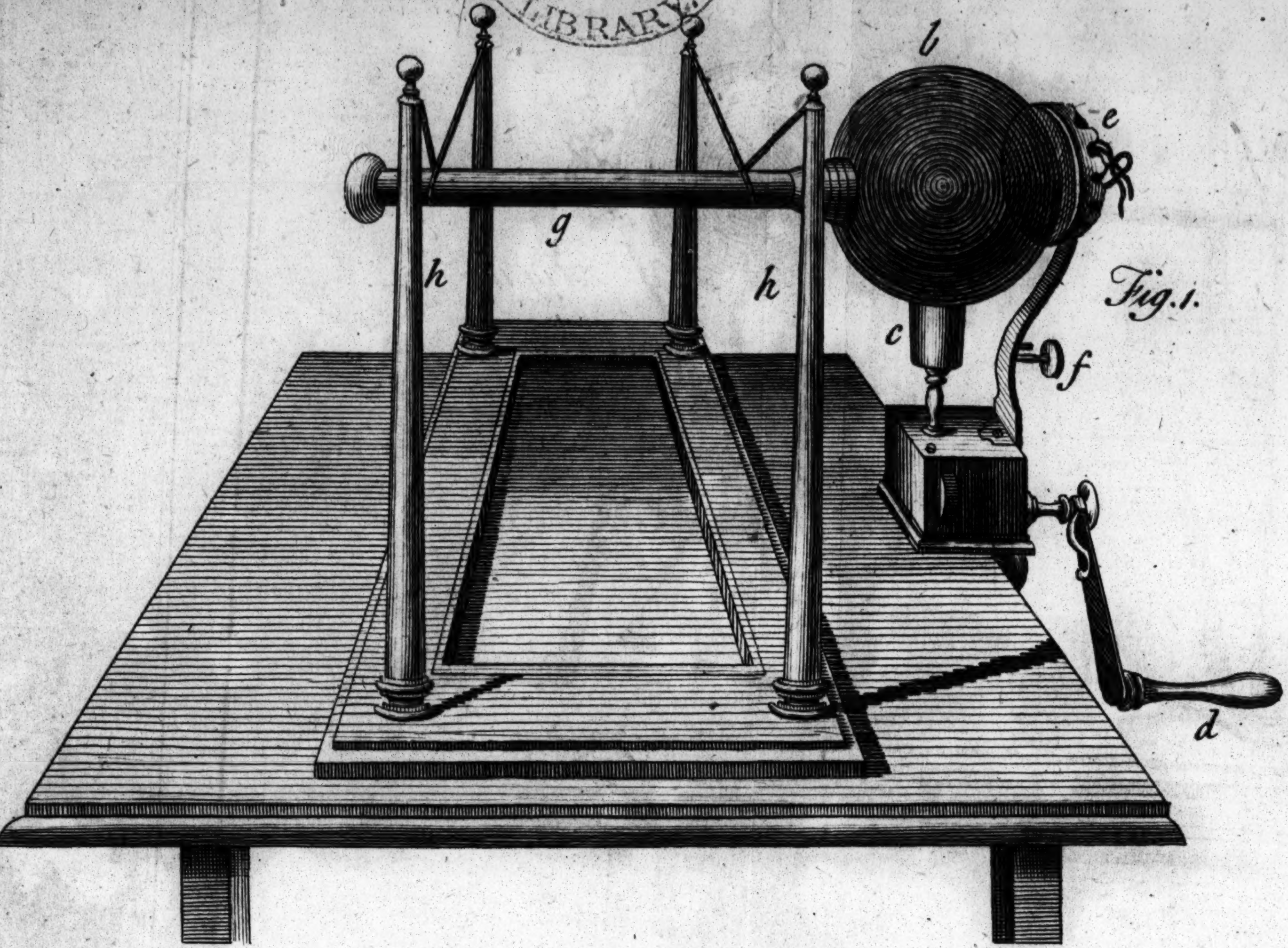

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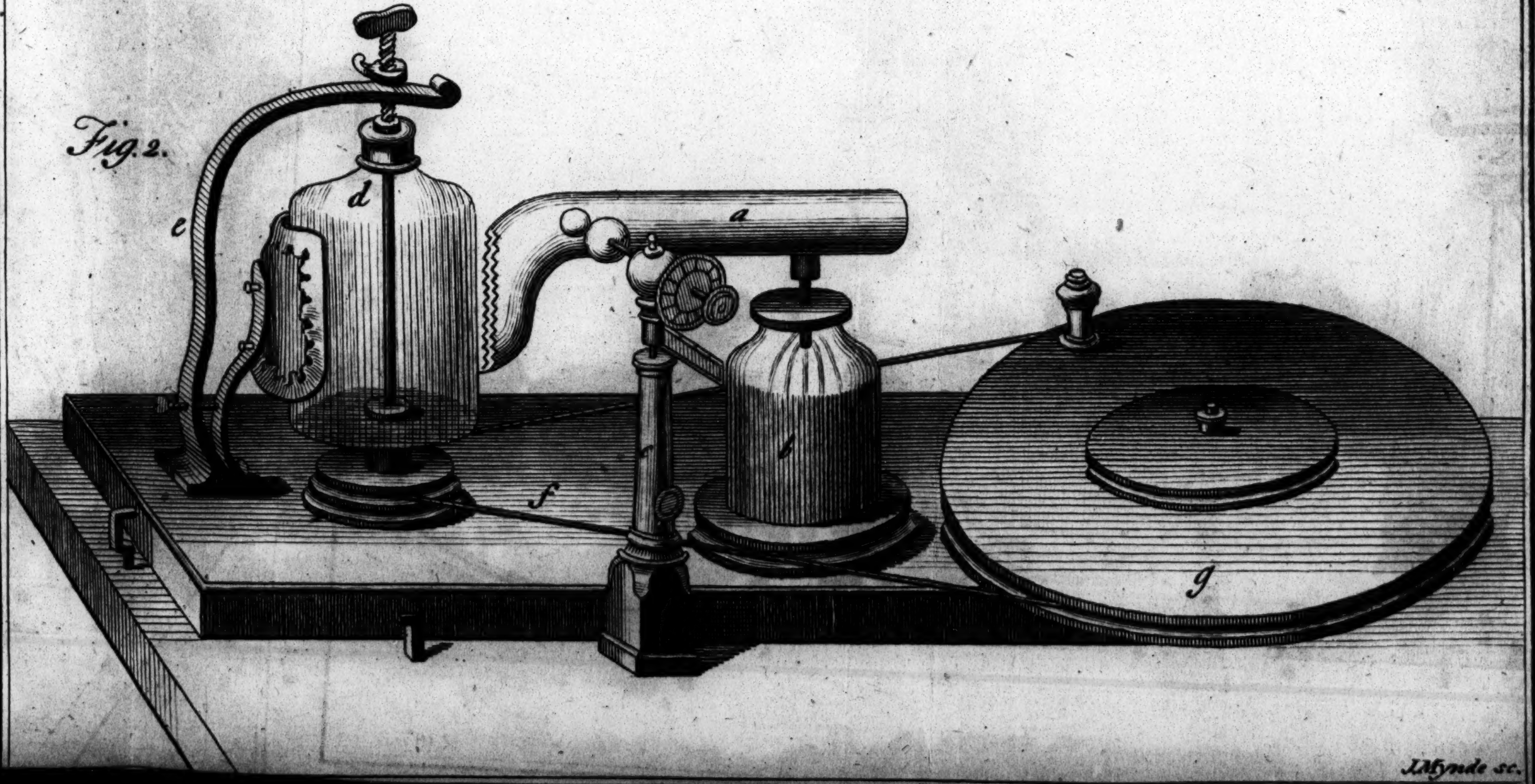

Fig. 2.

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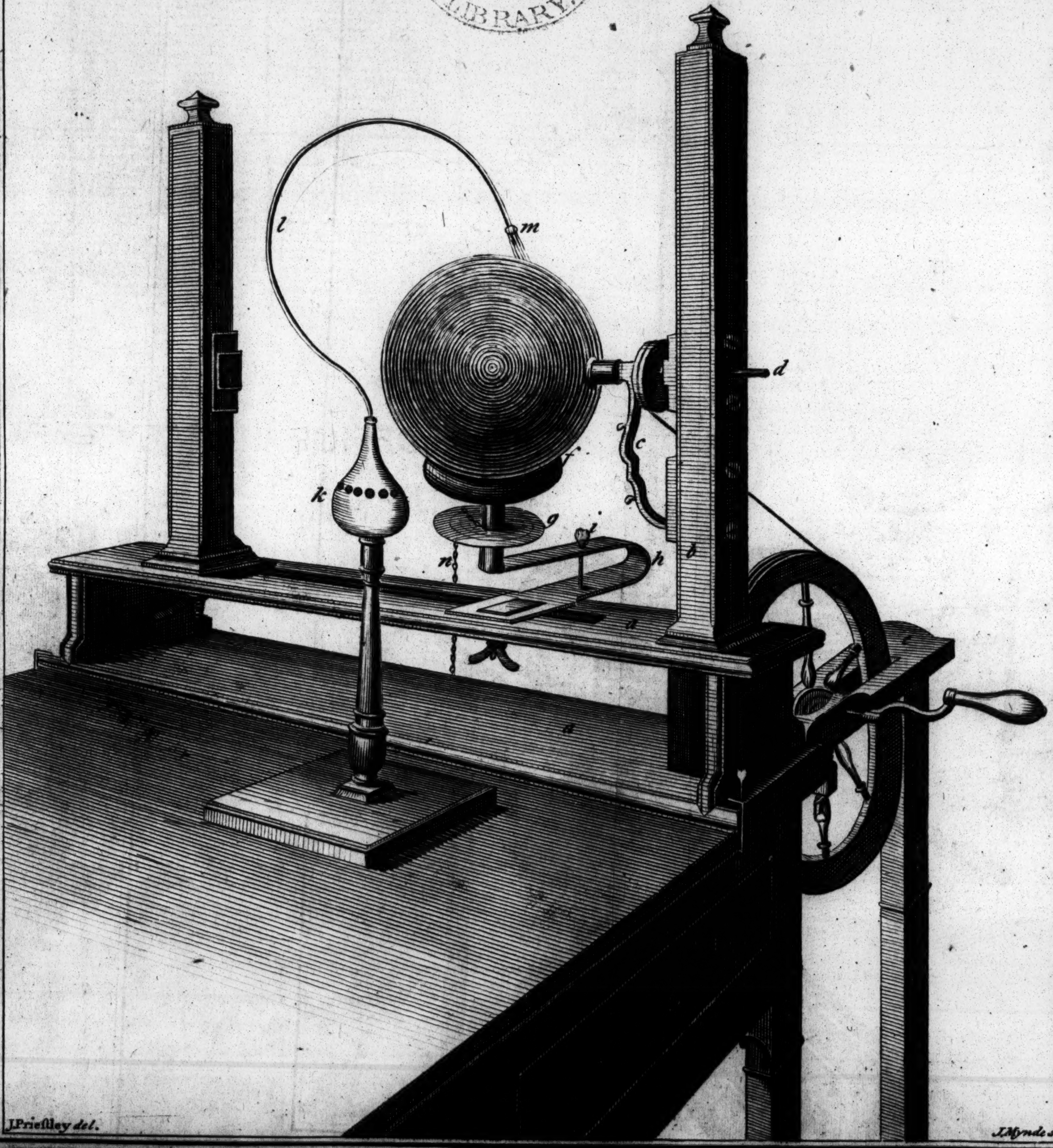

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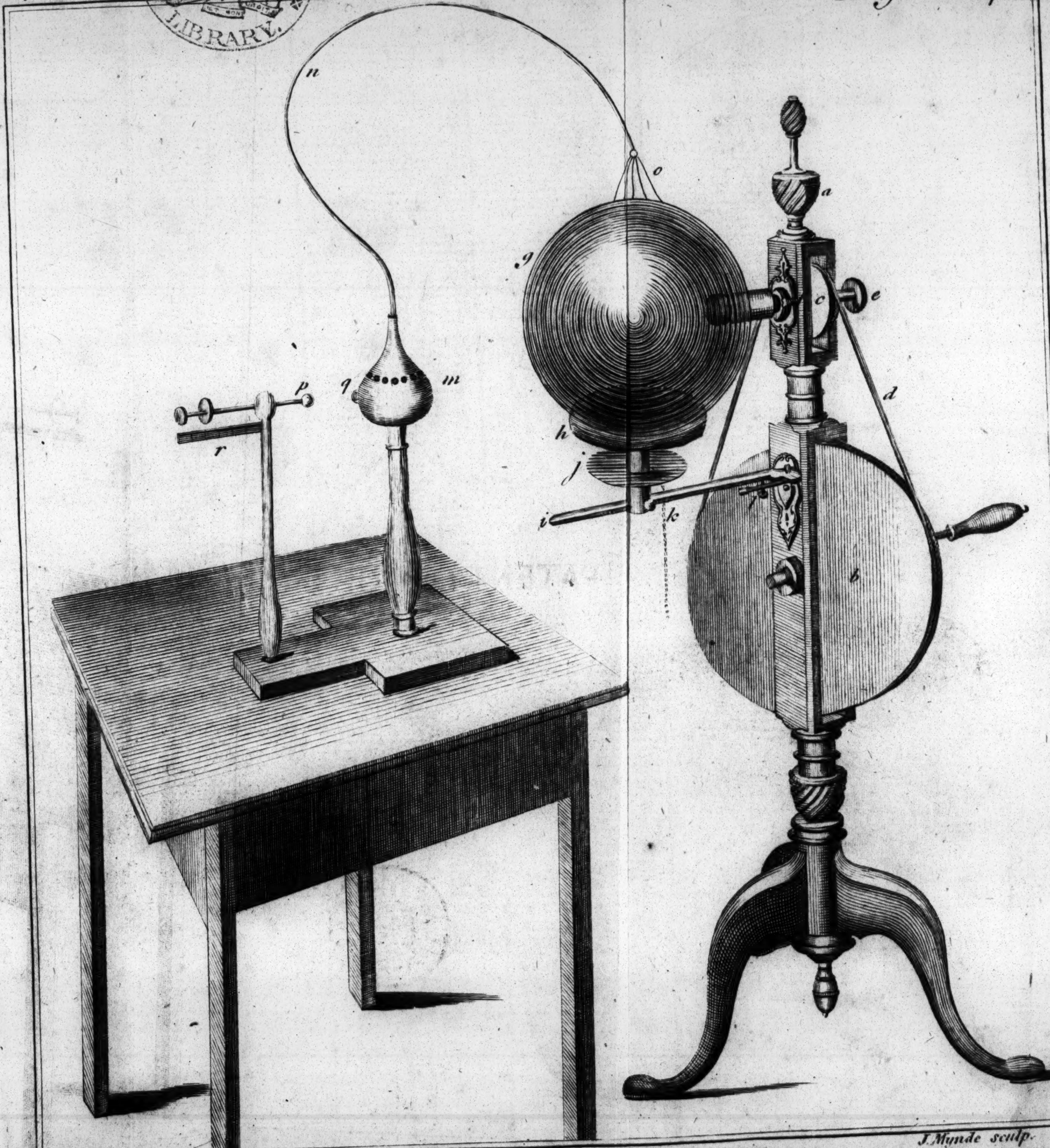

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